CLAIMS

1. An optical switch comprising:
at least two directing elements,
a first directing element including at least two sections,
a first section of said first directing element capable of receiving and transmitting a first section input beam,
said first section also being capable of controllably deviating said first section input beam in a first direction, and,
a second section of said first directing element capable of receiving and transmitting a second section input beam,
said second section also being capable of the controllably deviating said second section input beam in a second direction; and,

a second directing element including at least two sections
a first section of said second directing element capable of receiving and transmitting a second element first section incident beam, said second directing element first section incident beam being one of the first directing element transmitted beams,
said first section of the second directing element also being capable of controllably deviating in a second directing element first direction said second directing element first section incident beam, and,

a second section of said second directing element capable of receiving and transmitting a second directing element second section incident beam, said second directing element second section incident beam being another one of the first directing element transmitted beams, said second section of

the second directing element also being capable of deviating in a second directing element second direction said second directing element second section incident beam;

the first section input beam, the second section input beam, the at least two first element transmitted beams, and at least second two second element transmitted beams being substantially in a same plane.

2. The optical switch of claim 1 further comprising:

a free space propagation region capable of receiving and transmitting at least two free space propagation region incident beams, the at least two free space propagation region incident beams being at least two preceding element transmitted beams;

an output directing element including at least two sections,

a first section of said output directing element capable of receiving and transmitting an output directing element first section incident beam, said output directing element first section incident beam being one of the free space region transmitted beams,

said first section of the output directing element also being capable of controllably deviating in an output directing element first direction said output directing element first section incident beam, and,

a second section of said output directing element capable of receiving an output directing element second section incident beam, said output directing element second section incident beam being another one of the free space region transmitted beams,

said second section of the second directing element also being capable of controllably deviating in an output directing element second direction said

output directing element second section incident beam;

the at least two free space region transmitted beams, at least two output directing element transmitted beams, the first section input beam, the second section input beam, the at least two first element transmitted beams, and the at least two preceding element transmitted beams being substantially in the same plane.

3. The optical switch of claim 1 further comprising:
at least two displaced directing elements adjacent to and in a stack relationship with respect to said at least two directing elements,
a first displaced directing element, adjacent to and in a stack relationship with respect to said first directing element, the first displaced directing element including at least two sections,
a first displaced section of said first displaced directing element capable of receiving and transmitting a first displaced section input beam,
said first displaced section of the first displaced directing element also being capable of controllably deviating said first displaced section input beam in the first direction, and,
a second displaced section of said first displaced directing element capable of receiving and transmitting a second displaced section input beam,
said second displaced section of the first displaced directing element also being capable of controllably deviating in the second direction said second displaced section input beam; and,

a second displaced directing element, adjacent to and in a stack relationship with respect to said second directing element, including at least two sections,

a first section of said second displaced directing element capable of receiving and transmitting a second displaced directing element first section incident beam, said second displaced directing element first section incident beam being one of the first displaced directing element transmitted beams, said first section of the second displaced directing element also being capable of controllably deviating said second displaced directing element first section incident beam in a second displaced directing element first direction, and,

a second section of said second displaced directing element capable of receiving and transmitting a second displaced directing element second section incident beam, said second displaced directing element second section incident beam being another one of the first displaced element transmitted beams,

said second section of the second displaced directing element also being capable of deviating said second displaced directing element second section incident beam in a second displaced directing element second direction;

the first displaced section input beam, the second displaced section input beam, the at least two first displaced directing element transmitted beams, and at least second two second displaced directing element transmitted beams being substantially in a same displaced plane, the same displaced plane being adjacent to, in a stack relationship with respect to and substantially parallel to the plane containing the first section input beam, the second section input beam, the at least two first element transmitted beams, and at least second two second element transmitted beams.

4. The optical switch of claim 3 further comprising:

at least one upper cross shifting element optically disposed to receive previous element transmitted beams, the upper cross shifting element including at least two sections,

(1) a first upper cross shifting section capable of receiving and transmitting one of the previous element transmitted beams,

said first upper cross shifting section also being capable of controllably deviating one of the previous element transmitted beams in a first upper cross shifting direction,

the first upper cross shifting direction having a component perpendicular to the plane containing the first section input beam, the second section input beam, the at least two first element transmitted beams, and at least two previous element transmitted beams, and,

a second upper cross shifting section capable of receiving and transmitting another one of the previous element transmitted beams,

said second upper cross shifting section also being capable of the deviating said another one of the previous element transmitted beams in a second upper cross shifting direction,

the second upper cross shifting direction having a component perpendicular to the plane containing the first section input beam, the second section input beam, the at least two first element transmitted beams, and the previous element transmitted beams; and,

at least one displaced cross shifting element optically disposed to receive previous displaced directing element transmitted beams, the displaced cross shifting element including at least two sections,

a first displaced cross shifting section capable of receiving and transmitting one of the previous displaced directing element transmitted beams, said first displaced cross shifting section also being capable of controllably deviating in a first displaced cross shifting direction said one of the previous displaced directing element transmitted beams,
the displaced upper cross shifting direction having a component perpendicular to the displaced plane, and,

a second displaced cross shifting section capable of receiving and transmitting another one of the previous element transmitted beams, said second upper cross shifting section also being capable of the deviating said another one of the previous displaced directing element transmitted beams in a second upper cross shifting direction, the second displaced cross shifting direction having a component perpendicular to the displaced plane.

5. The optical switch of claim 1 wherein each one of said at least two sections of each one said at least two directing elements includes a switchable volume grating, said first direction corresponding to a blazing state of a first section first directing element switchable volume grating, said second direction corresponding to a blazing state of a second section directing element switchable volume grating, said second directing element first direction corresponding to a blazing state of a first section second directing element switchable volume grating, said second directing element second direction corresponding to a blazing state of a second section second directing element switchable volume grating.

6. The optical switch of claim 1 wherein the at least two sections comprise 2N sections, N being a positive integer greater than one; and,
wherein the at least two directing elements comprise 2N + 1 directing elements.

7. The optical switch of claim 1 wherein the at least two sections comprise N sections, N being an odd positive integer greater than one; and,
wherein the at least two directing elements comprise N + 1 directing elements.

8. The optical switch of claim 5 wherein the second directing element first direction is the second direction and the second directing element second direction is the first direction.

9. The optical switch of claim 8 wherein the at least two sections comprise 2N sections, N being a positive integer greater than one; and,
wherein the at least two directing elements comprise 2N + 1 directing elements; and,
wherein the first directing element includes N groups of sections,
each group from the N groups including two sections,
a first section capable of receiving and transmitting an input beam from a plurality of input beams and also being capable of controllably deviating said input beam from the plurality of input beams in the first direction, and,
a second section capable of receiving and transmitting another input beam from the plurality of input beams and also being capable of controllably deviating said another input beam in the second direction; and,

the second directing element includes N groups of sections,

each group from the N groups including two sections,
a first section capable of receiving and transmitting a transmitted beam from a plurality of first element transmitted beams and also being capable of controllably deviating said transmitted beam from the plurality of first element transmitted beams in the second direction, and,
a second section capable of receiving and transmitting another transmitted beam from the plurality of first element transmitted beams and also being capable of controllably deviating said another transmitted beam in the first direction; and,

wherein a group of succeeding elements, including the third element to the 2Nth +1 element, has a repeating pattern, the pattern comprising
one element including N groups of sections,
each group from the N groups including two sections,
a first section capable of receiving and transmitting a preceding element transmitted beam from a plurality of preceding element transmitted beams and also being capable of controllably deviating said preceding element transmitted beam in the first direction, and,
a second section capable of receiving and transmitting another preceding element transmitted beam from the plurality of preceding element transmitted beams and also being capable of controllably deviating said another preceding element transmitted beam in the second direction; and,
a next element including N groups of sections,
each group from the N groups including two sections,
a first section capable of receiving and transmitting a preceding element transmitted beam from the plurality of preceding element transmitted beams and also being capable of controllably

deviating said preceding element transmitted beam in the second direction, and,
a second section capable of receiving and transmitting another preceding element transmitted beam from the plurality of preceding element transmitted beams and also being capable of controllably deviating said another preceding element transmitted beam in the second direction.

10. The optical switch of claim 8 wherein the at least two sections comprise 2N sections, N being a positive integer greater than one; and,
wherein the at least two directing elements comprise 2N + 1 directing elements; and,
wherein the first directing element includes two groups of sections,
the first group including N first sections,
each of the N first sections being capable of receiving an input beam from a plurality of input beams and also being capable of deviating said input beam in the first direction, and,
the second group including N second sections, each of the N second sections being capable of receiving another input beam from the plurality of input beams and also being capable of deviating said another input beam in the second direction; and,
wherein the second directing element includes two groups of sections,
the first group including N first sections,
each of the N first sections being capable of receiving a first element transmitted beam from a plurality of first element transmitted beams from a plurality of input beams and also being capable of deviating said first element transmitted beam in the second direction, and,
the second group including N second sections, each of the N second sections being capable of receiving another first element transmitted beam from a plurality of first element transmitted beams and being capable of deviating

said another first element transmitted beam in the first direction; and,

wherein a group of succeeding elements, including the third element to the 2Nth +1 element, has a repeating pattern, the pattern comprising

one element including two groups of sections,

the first group including N first sections,

each of the N first sections being capable of receiving a preceding element transmitted beam from a plurality of preceding element transmitted beams and also being capable of deviating said preceding element transmitted beam in the first direction, and,

the second group including N second sections,

each of the N second sections being capable of receiving another preceding element transmitted beam from a plurality of preceding element transmitted beams and being capable of deviating said another preceding element transmitted beam in the second direction, and,

a next element including two groups of sections,

the first group of next element sections including N first sections,

each of the N first sections being capable of receiving a preceding element transmitted beam from a plurality of preceding element transmitted beams and also being capable of deviating said preceding element transmitted beam in the second direction, and,

the second group including N second sections,

each of the N second sections being capable of receiving another preceding element transmitted beam from the plurality of preceding element transmitted beams and being capable of deviating said another preceding element transmitted beam in the first direction.

11. A method for switching optical beams comprising the steps of:

a) selectively deviating in a first direction an upper one of at least two input beams;

b) selectively deviating in a second direction a displaced one of at least two input beams;

c) subsequently selectively deviating in a third direction an upper one of the at least two selectively deviated input beams;

d) subsequently selectively deviating in a fourth direction a displaced one of the at least two selectively deviated input beams.

12. The method of claim 11 wherein deviating is performed by means of a switchable volume grating; and, wherein said first direction corresponds to a first blazing state of a first switchable volume grating, said second direction corresponds to a second blazing state of a second switchable volume grating, , said third direction corresponds to a third blazing state of a third switchable volume grating, said fourth direction corresponds to a fourth blazing state of a fourth switchable volume grating.

13. The method of claim 11 wherein the at least two input beams comprise 2N input beams, N being a positive integer greater than one; and

wherein the method further comprises the steps of:

repeating steps (a) and (b) for each successive two beams from the 2N input beams, starting at a first input beam;

repeating steps (c) and (d) for each successive two beams from the 2N selectively deviated input beams;

repeating 2N-1 times a sequence of steps comprising the steps of:

repeating N times the steps of:

subsequently selectively deviating in the first direction an upper one of each

successive two beams from the 2N previously selectively deviated beams;
subsequently selectively deviating in the second direction a displaced one of each successive two beams from the 2N previously selectively deviated beams.

14. The method of claim 11 wherein the third direction is the second direction and the fourth direction is the first direction.

15. The method of claim 13 further comprising the step of:
propagating, after repeating executing 2N-2 steps in the repeating sequence, the 2N previously selectively deviated beams through a free space region.